Microstructure and Mechanical Properties of Nanocrystalline Zr1.0Nb Alloy Obtained by Equal Channel Angular Pressing

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Keywords: Zr1.0Nb alloy, microstructure, grain refinement, tensile strength, microhardness

Abstract. Recently Zirconium (Zr) alloys obtained new applications as a material for dental and orthopedic implants [1, 2]. Mechanical properties as functional ones are very important for such applications. The changes of microstructure and mechanical properties of Zr1.0Nb alloy processed by Equal Channel Angular Pressing (ECAP) was investigated in this work. ECAP is known to induce the grain refinement of metals and metallic alloys, which in turn improves their mechanical characteristics [3].

Experimental. The analysis of the microstructure, dislocation structure and grain size of Zr1.0Nb alloy before and after ECAP was performed by means of transmission electron microscopy (TEM). The mechanical properties were investigated by using the uniaxial static and cyclic tension and microindentation tests. The fractography analysis was applied to study the fracture mechanisms.

Results. The TEM results showed the initial grains size of Zr1.0Nb alloy, before ECAP, to be 1.1-2.4 μm, which decreased to 70-280 nm after ECAP processing. Three types of grains were identified depending on their

dislocation structure. The microhardness values exhibit an increase from 1.4 to 1.93 GPa induced by ECAP. The yield and ultimate tensile strength increased as well from 324 to 397 MPa and from 420 to 588 MPa, respectively; at the same time the elongation at failure decreased from 20.2% to 10.8%. Fatigue strength did not show substantial changes for high stresses and demonstrated a drop from 225 to 150 MPa for low stresses. Zr1.0Nb alloy demonstrated mostly ductile fracture mechanism for both before and after ECAP. A transition to quasi-brittle fracture was noticed for low stresses cyclic tension test for ECAP Zr1.0Nb alloy.

*Conclusions***.** The ECAP processing of Zr1.0Nb alloy demonstrated a grain refinement up to nanometer size. The obtained nanocrystalline structure led to the improvement of mechanical properties manifested in higher strength and hardness and the same time in rather high fatigue and fracture resistance.

Acknowledgments. This study was fulfilled in the frame of the research Subprogram **011201** of the Institute of Applied Physics, Moldova State University.

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